REMARKS

After entry of this amendment, claims 1-30 are pending in the application. Claims 1-18 are currently withdrawn, subject to rejoinder after indication of an allowable linking claim. Claims 1, 10, 19-22, and 29-30 have been amended to more particularly point out and distinctly claim the subject matter which applicant regards as the invention, and to overcome rejections of the claims based on 35 U.S.C. §112, second paragraph. Reconsideration of the application as amended is requested.

In the office action dated January 21, 2004, the Examiner rejected claims 20-23 and 29-30 as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. The Examiner noted specific phrases which have been carefully reviewed and amended in order to overcome the rejection under 35 U.S.C. §112, second paragraph. Reconsider of the claims as amended and withdrawal of the Examiner's rejection is requested.

The Examiner requested that paragraph [0002] be updated to reflect the issuance of the related application in the present application. Paragraph [0002] has been amended to reflect U.S. Patent No. 6,677,769 which issued January 13, 2004. Reconsideration of the Examiner's objection to the specification is requested.

Claims 19 and 24-28 are rejected under 35 U.S.C. §102(b) as being anticipated by Zhang et al. (U.S. Pat. No. 5,952,818). It is submitted that the Zhang et al reference does not anticipate, teach or suggest the present invention as recited in claims 19 and 24-28. In particular, the physical phenomena used for temperature measurement and the temperature compensation of electric field information in the present invention is totally different than the fundamental basis used in the technique in the cited Zhang et al patent. In fact, the physical principle used for temperature sensing and signal compensation for thermal effects is not mentioned in Zhang et al. The Zhang et al reference is only relevant because it teaches that GaAs can be used for electro-optic measurements of

electric fields. The uniqueness afforded by GaAs for measuring electric field <u>and temperature (and for compensating the electric-field measurement for thermal effects)</u> is only described in the present invention. The bandgap modulation used and claimed in the present invention is never mentioned in the Zhang et al reference, and the joint electric-field/thermal measurement capability of the present invention is not anticipated, taught or rendered obvious by any cited reference including Zhang et al. The present invention uses a value associated with the attenuation of a part of the optical return signal that does not contain information on the electric field to correct the size of the signal that does contain information on the electric field. The present invention has an optical beam that carries (1) information about both the electric field and temperature at a modulation frequency component of f1 MHz; and (2) information about temperature only at a modulation frequency component of f2 MHz. The information included in the f2 MHz component can be used to compensate for temperature effects included in the electric-field information in the f1 MHz component of the optical beam. In the present invention, the frequencies below a first threshold are the ones containing the information on the electric field to be measured. The frequencies above the first threshold contain both amplitude and phase information about the electric field signals to be measured, as well as information on the temperature of the probe, while frequencies above a second threshold contain information about the temperature of the probe only. In the present invention, the information in the frequencies above the second threshold is used to compensate for the effects of temperature on the electric field information. None of the cited patents, including Zhang et al, use this technique. The optoelectronic technique of the present invention uses bandgap modulation in the same material used to sense the electric field. In other words, the present invention uses a measured quantity (absorption of one specific portion of the optical signal, i.e. the part carrying only thermal information) to compensate for temperature effects on a different portion of the optical beam (i.e., the part carrying a combination of electric-field and thermal information). The present

invention can be used for measuring radio frequency and microwave signals, either free-space or guided.

Conventional, universally accepted microwave measurements on linear devices, circuits, antennas, arrays of radiation sources, etc. are carried out in the frequency domain, while the component being tested is operating in a steady-state condition (i.e., with a continuous-wave, or cw, microwave input). Properties typically extracted are microwave-signal power (related to the square of the electric field) and electric field phase angle. The apparatus according to the present invention seeks to characterize microwave components in this steady-state mode, and in particular in the near field of the element. A microwave probe either needs to be of matched impedance, if it is to measure at the input and output ports of the device under test (DUT), or of a high impedance if it is to measure at other locations, such as the interior (or internal nodes) of a DUT or in the "near field" of a DUT. A high impedance probe measuring in the near field of a DUT, where there exists unique electric-field information that has typically never before been accessed, must disturb the DUT as little as possible. An issue is thus that the probe have no metal parts, that it be small (in relation to the microwave wavelength to be measured), and that it have a reasonably low dielectric permittivity. In order to avoid the disturbance of the electric field to be measured, and to obtain the highest possible spatial resolution for the electric field, the present invention has used a very small (micromachined) probe in a scanning configuration, and has not tried to manipulate the electric field to be measured (e.g., to focus it on the EO probe) before it enters the probe. It happens that the probe according to the present invention is general enough that it could measure any sufficiently strong field distribution, in the far field as well as the near. Zhang's disclosure is exclusively oriented towards the measurement of a transient, terahertz-bandwidth signal in the far field, not of a steady-state signal in a location that could include the near field. Zhang's experimental configurations exclusively measure transient, radiated signals that are generated optically and that must be triggered by a part of the laser beam split off from the

beam that passes through the probe medium. Zhang's systems are not capable of accurately measuring guided-wave signals, as the apparatus according to the present invention is, nor has the Zhang patent presented any way in which steady-state, cw signals could be measured. (Zhang's disclosure specifically says the methodology is for measuring propagating, far-field signals.) In addition, Zhang does no scanning of the probe, the smaller probe employs a large lens in front of it, and the alternate configuration of a large, plate-like probe, would dramatically influence the near-field pattern of a DUT. As a consequence, any of the described systems of Zhang would be rendered ineffective at extracting realistic near-field radiation patterns or guided waves from a DUT. While the Zhang patent does show the far-field radiation pattern for a THz antenna, the antenna is driven by a transient optical source, not a cw microwave source, and furthermore, the primary application of the EO sensing methodology is to measure the transient field transmission through an object that Zhang wishes to image. That is, the true goal of Zhang's disclosure is not to image the field from a microwave circuit or antenna, but rather to image an object using the field that has passed through it and been manipulated by it. In Zhang's system, a short-pulsed electromagnetic (EM) wave generation and electro-optic detection system are designed to achieve time domain (transient) signal measurement. The short-pulsed EM wave is used for the characterization of i) the medium between the transmitter (Fig.1, 26) and receiver (Fig.1, 14), or ii) an object placed between the two devices. Zhang does not directly measure amplitude and phase of the electric field at any given frequency, but rather Zhang needs to rely on numerical computations, specifically a Fast Fourier Transform (FFT), in order to quantify the amplitude and phase information.

In the present invention, an electro-optic field mapping system is designed to directly achieve 1-D, 2-D, and 3-D frequency domain (steady state) electric field distribution mapping (simultaneously for the amplitude and phase) over an arbitrary electric/electronic device in order to characterize some aspect of the device that radiates or guides the electric field. The system according to the

present invention can be applied for i) performance validations, ii) fault isolations, and iii) cross-talk examination of various electric circuits and radiators with frequency ranges from 80 MHz to more than 100 GHz.

In Zhang, the system relies on free-space optical components to control the direction and polarization of the optical beam. In particular, the system uses free-space beam to the transmitter and receiver. As a result, the movements of the transmitter or receiver are substantially limited due the beam alignment issue. (Note, the Zhang disclosure does say that a fiber could be used to bring the laser light to the probe, but it says nothing of the same fiber being used to guide the light reflecting from the probe, nor does it say anything about integrating polarization-controlling elements with the optical fiber.)

In the present invention, the system relies on optical fiber connection to the EO sensor and corresponding integrated polarization control devices. As a result, the optical connection between the laser and EO sensor can be secured regardless of the position or direction of the EO sensor, which is a significant advantage for the characterization of various electric/electronic devices. Due to the original purpose of Zhang's system, it requires a radiation source (26, Fig.1) as a part of the system in order to generate the short-pulsed electromagnetic signals (12) that are eventually detected by the sensor. However, the system according to the present invention is designed to characterize a wide variety of electric devices (both radiating electromagnetic waves, as well as supporting guided waves), it is not necessary to include any kind of specific radiator into the system.

Zhang's system needs to divide the input optical beam into two parts, and one of the parts has to pass a time-delay control device (e.g. 28, Fig.1) for proper system operation. However, since the system according to the present invention does not rely on timing differentiation for its operation, the input beam is not divided into two parts, and furthermore, no timing control device is necessary. The present invention uses synchronization between the laser pulses

and a continuous wave (cw) microwave source, along with a harmonic mixing technique, instead of a time-delay device.

In Fig. 1, for Zhang's system, the receiver employs a hyper-hemisphere silicon lens to focus the EM wave to be measured onto the EO sensor. However, in system according to the present invention, the EO sensor (attached at the end of the fiber via GRIN lens) does not require any kind of field focusing structure. Moreover, it is more desirable not employing any additional structure into the EO sensor in order to achieve accurate field measurement.

In Zhang's system, the receiver EO crystal employs a total internal reflection configuration or a transmission configuration. However, in the system according to the present invention, the EO sensor employs a high reflective (HR) coating, consisting of multiple dielectric layers, which provides a significant advantage for the miniaturization of the probe.

In Zhang's system, the incident beam directed toward the receiver and the reflected beam from the receiver have paths that are spatially separated by free-space optical components (such as mirrors), and only the reflected beam is directed to the detector(s). However, in the system according to the present invention, the difference of the polarization status of the incident and reflected beams is used to separate the two beams that are traveling along an identical path. This is one of the features of the system according to the present invention that makes a fiber-based EO system feasible.

With respect to claims 19-30, it is submitted that while the general language describing the Zhang system and the present invention appear to be nearly the same, the specifics of the two disclosures are quite different. The individual phrases and words that are the same or similar will now be discussed in order to describe how the phrases and words differ in meaning within the two disclosures.

(1) "Means for generating an optical (probe) signal." The laser used in the Zhang patent is a different source than the present invention in terms of operating wavelength (820 nm vs 910 nm) and pulse repetition rate (150 fs vs 100 fs).

(2) "Electro-optic field mapping sensor." (30 in Zhang et al) The Zhang patent referred to an electro-optic field mapping sensor 30 as a static device that is integrated with a terahertz EM pulse generation apparatus (transmitter 29 and relevant free-space optical component 24), a time-delay control mechanism (delay stage 28), a terahertz receiver 32, and its relevant free-space optics. Furthermore 30 includes photodetector unit 18. The sensor is not scanned to yield a field image (which one might consider an advantage, except that it also means that the sensor can't be used to accurately and noninvasively measure guided wave signals or radiating signals in the near field). However, in the system according to the present invention, an electro-optic field mapping sensor refers to a miniaturized (or micromachined) electro-optic crystal mounted at the end of optical fiber, and it gets its field-mapping capability from the fact that it (and it's accompanying GRIN lens and optical fiber connection) is physically scanned in 2 dimensions of space. (3) The present invention senses a reflected optical signal from the probe; while the Zhang reference states that it senses the optical probe signal that has impinged on the EO sensor. In the Zhang patent, elements 24, 28, and 31 represent components used for control of beam direction (such as mirrors, to reflect optical beams around) and have no direct effect on the determination of electro-optic effect. While in the present application, the reflected optical signal means the optical beam reflected at the bottom (or unattached side) of the EO crystal due to the presence of high reflection coating consisting of multiple dielectric layers. As thus, it has significant impact on the performance of the EO sensor, and furthermore, it separates the method of the present invention from the Zhang patent where a total internal reflection scheme (Fig. 1, Fig. 2, Fig. 3, Fig. 17, Fig. 18) is used. In Fig. 4, the system shows transmitting schematic for the EO sensor where the beam transmits through the EO crystal (rather than being reflected), which is a completely different schematic than the present invention. (4) The present invention senses a free-space electromagnetic field associated with a workpiece to be tested, while Zhang senses a free-space electromagnetic field. While Zhang's phrase is more general, it refers to (and is defined in the

disclosure as) a propagating wave in the far field. Thus the E-field does not have to be associated with a workpiece. In the present invention, the field is described as free-space not to imply far field radiation, but rather to indicate that the field does not need to be coupled into a device such as an electro-optic Pockels cell modulator in order to be measured. It exists in space, but it does not have to be radiated, nor does it have to be in the far field. Hence it is associated with a workpiece to be characterized. Also, the element 18 in the Zhang patent represents a photodetector that has no relationship with the workpiece of the present application. (5) The present application senses polarization modulation; while the Zhang reference discloses ellipticity modulation. The polarization modulation is the effect that occurs inside of EO crystal due to the Pockels effect and the presence of an electric field in it. However, the polarizer of Zhang et al (Fig. 24) is an optical component that provides polarization control and has no relationship with the Pockels effect. Also the term tested by analyzing from the present application means the resultant EO signal can be analyzed for the evaluation (or characterization) of the workpiece (devices or antennas under test), while the analyzer of Zhang et al (Fig. 27) language means a simple optical device including a waveplate and polarizer. When the present application refers to tested by analyzing the polarization modulation, the present application is describing passing the modulated optical beam through a waveplate and a polarizer and then into a photodetector, after which the resulting electrical signal is directed to a lock-in amplifier and the reduced data displayed on a computer.

The EO crystal in the Zhang patent (14 in Fig. 1) has a crystal with a predetermined orientation because it has to be aligned correctly with respect to the one possible polarization from the required THz emitter (26 in Fig. 1) in order to optimize sensitivity. However, the system according to the present invention is not used to measure such radiation sources, and the orientation of the crystal has a predetermined orientation because this distinguishes which polarization from an arbitrary workpiece will be measured.

It is true that the Zhang patent mentioned the possibility of using a fiber optic link at the output of the sensor. However, there is no detailed description provided regarding the mounting process. Mounting an EO crystal at the end of fiber requires a number of technical steps. As a matter of fact, a great degree of variation can exist for the realization of EO crystal mounting. The Examiner is referred to the summary of the invention and description of the drawings of the present application for more details. In particular, the fiber optic assembly according to the present invention is not merely a fiber optic link from the sensor. Rather according to the present invention, the optical fiber provides an input and output route along the same path for the optical beam, and it is coupled to the sensor using a graded-index (GRIN) lens. Furthermore, it is integrated with the polarization-controlling mechanism that is employed in the evaluation of the optical output beam from the sensor, and it is moved by an X-Y translation stage according to the present invention in order to effect the scanning of the probe through the field associated with the workpiece.

Applicant and applicant's attorney could not find any description of the use of a gradient index lens in the Zhang patent. Numeral 20 is a lens, but it is a hyperhemispherical lens used to couple transient THz radiation (the only electric field measurable by the Zhang apparatus) into the electro-optic sensor. The GRIN lens according to the present invention is used to couple the probe optical light beam into and out of the EO sensor, not to couple the electric field to be measured into the EO sensor.

The Zhang reference describes using a <110> ZnTe crystal for the EO sensor, but there is no comment on using ZnTe crystals of different orientations for this purpose. (The present invention uses the ZnTe crystals to detect different polarization components of the electric field to be measured.) Also, the Zhang reference never mentions the use of different orientations of any GaAs (micromachined included) for the EO sensor crystal. The Zhang reference does indicate that GaAs crystals of different orientations could be used for the photoconductive generation of the THz transients (i.e., using the GaAs as the

transmitter - an element the present invention does not require for the disclosed system.). This use of <100> and <110> GaAs has no relationship to the application of those GaAs crystals as EO sensors.

The Zhang reference never mentions any use of an EO sensor for detecting more than one polarization of the electric field to be measured. Figure 17, 18, and 19 show the variety of EO crystal shapes that can be employed in order to achieve total internal reflection, which is critical for the Zhang system. However, different shapes of the EO crystal do not imply different crystal orientations, or that the shapes can be used to detect different vector components of the electric field polarization. As a matter of fact, in the system described in the Zhang patent, the polarization of the EM pulse is fixed by the orientation of the transmitter (26 in Fig. 1, 29 in Fig. 4). Furthermore, the Zhang reference specifically states that the distance between the transmitter and EO sensor puts the latter in a far field position (column 14, line 8-12), which implies only EM waves that have a polarization parallel to the surface of the EO sensor can reach the receiver. Therefore, there would be no reason to have an EO sensor that would have sensitivity to an electric-field polarization normal to the surface of the sensor (i.e., a normal-field sensitivity), nor any reason to detect three orthogonal polarizations.

The Zhang reference never mentions that it can measure microwave fields. The Zhang reference states that the system can be used for imaging a field distribution (Fig. 28a caption), however the Zhang reference never indicates that it can map an electric field. The system described in the Zhang patent uses, in one embodiment, an electro-optic plate and a two-dimensional imaging system such as CCD camera to capture the field distribution. However, in the system according to the present invention, a miniaturized EO crystal is used that can be considered as a point sensor with respect to the EO crystal plate disclosed in the Zhang patent. Also, by introducing two-dimensional (or even 3-D) movement of the EO probe, complete field mapping can be achieved over an arbitrary device or antenna workpiece under test with the present invention. As well as the

freedom of the field mapping range and type (point, 1-D [line], 2-D [plane], or 3-D), in the system according to the present invention, the resolution of the field mapping can be easily controlled by setting the size of the movement step of the X-Y translation stage controlling the EO sensor. This field image resolution was fixed by the resolution of the CCD imager in the Zhang patent.

The imaging referred to by the Zhang reference in col. 29, lines 5-14 is not of an electric field, but of an object through which an electric field has passed. For example, the Zhang reference is imaging of an object placed between the transmitter and receiver (Fig. 16) using the EM transient generated by the transmitter, while the system according to the present invention is designed to map microwave electric field distributions emanating from an arbitrary device or antenna. Furthermore, the Zhang patent discloses only that the system can map the electric field from a certain type of THz antennas (Fig. 29A, 29, 30A, 30,31A, 31). However, those antennas are activated using part of the input beam (divided by an optical beam splitter 24 in Fig.1), and the antennas cannot be considered as arbitrary antennas under test that are totally independent of the rest of the system. As a result, the system described in the Zhang patent has only limited capability for the characterization of special antennas that can be excited by optical pulses, while the system according to the present invention can be applied to any arbitrary antennas or circuits. The Zhang reference never mentions that it can determine whether a workpiece to be tested is defective.

No mention is made in Zhang's patent about spatial scanning of EM fields in one part of a microwave workpiece, nor within an enclosed microwave package. The Examiner may have noticed that a scanning delay rail is used by Zhang to look at the electric field versus time, but that does not give any information about the fields in one particular part of a workpiece. Zhang's scanning stage is used to monitor field in the realm of time, while the present invention is used to measure field in the realm of space. Reconsideration of the Examiner's rejection of claims 19 and 24-28 is requested.

This after final amendment: (1) does not raise new issues that would require further consideration and/or search, since the proposed amendments incorporate previously recited limitations from dependent claims into the independent claims and these limitations have been previously considered and searched by the Examiner; (2) does not raise the issue of new matter, since the proposed amendments have support in the originally filed application including the specification, claims and drawings; (3) does places the application in better form for appeal by materially reducing and/or simplifying the issues for appeal; and/or (4) does not present additional claims without cancelling a corresponding number of finally rejected claims. The after final amendment was necessitated due to the Examiner's reliance on the newly cited reference to Zhang et al. This amendment could not have been earlier presented, since the Examiner had not relied on the Zhang et al reference previously, so this is Applicant's attorney's first opportunity to address the Examiner's rejection based on this reference.

It is respectfully submitted that this Amendment traverses and overcomes all of the Examiner's objections and rejections to the application as originally filed. It is further submitted that this Amendment has antecedent basis in the application as originally filed, including the specification, claims and drawings, and that this Amendment does not add any new subject matter to the application. Reconsideration of the application as amended is requested. It is respectfully submitted that this Amendment places the application in suitable condition for allowance; notice of which is requested.

A personal interview was requested of the Examiner, but an interview could not be scheduled on the date requested. The Examiner is requested to grant a telephone interview to discuss the claims and cited reference in order to expedite prosecution of the present application. If the Examiner feels that prosecution of the present application can be expedited by way of an Examiner's amendment, the Examiner is invited to contact the Applicant's

attorney at the telephone number listed below.

Respectfully submitted,

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